2013

Agronomic, Environmental, and Economic Performance of Alternative Biomass Cropping Systems (The Landscape Biomass Project)

Lisa A. Schulte-Moore
Iowa State University, lschulte@iastate.edu

Richard B. Hall
Iowa State University, rbhall@iastate.edu

Kenneth J. Moore
Iowa State University, kjmoore@iastate.edu

Emily A. Heaton
Iowa State University, heaton@iastate.edu

Arne Hallam
Iowa State University, ahallam@iastate.edu

See next page for additional authors

Agronomic, Environmental, and Economic Performance of Alternative Biomass Cropping Systems (The Landscape Biomass Project)

Abstract
The goal of the Landscape Biomass Project is to develop a portfolio of biomass cropping systems that together are productive, profitable, and mitigate the negative effects of annual crops on soil and water quality. To accomplish this goal, we have developed several alternative biomass cropping systems and compared them with a conventional continuous corn system. Alternative cropping systems were chosen because of their potential to provide superior biomass yields (triticale/sorghum); some biomass yield while mitigating some negative environmental impacts (corn-soy-triticale/soy and corn-switchgrass); or some short-term biomass yield and superior long-term yield while strongly mitigating negative environmental impacts (triticale/aspen). As crop performance is strongly tied to site factors, we are evaluating these bio-mass cropping systems across a series of landscape positions.

Keywords
RFR A12127, Natural Resource Ecology and Management, Agronomy

Disciplines
Agricultural Science | Agriculture | Agronomy and Crop Sciences | Natural Resources Management and Policy

Authors
Lisa A. Schulte-Moore, Richard B. Hall, Kenneth J. Moore, Emily A. Heaton, Arne Hallam, Theodore P. Gunther, and Robert Manatt

Agronomic, Environmental, and Economic Performance of Alternative Biomass Cropping Systems (The Landscape Biomass Project)

RFR-A12127

Lisa Schulte-Moore, associate professor
Richard Hall, professor
Department of Natural Resource Ecology and Management
Kenneth Moore, distinguished professor
Emily Heaton, assistant professor
Department of Agronomy
Arne Hallam, associate dean
Liberal Arts and Sciences
Theo Gunther, graduate assistant
Robert Manatt, undergraduate

Introduction

The goal of the Landscape Biomass Project is to develop a portfolio of biomass cropping systems that together are productive, profitable, and mitigate the negative effects of annual crops on soil and water quality. To accomplish this goal, we have developed several alternative biomass cropping systems and compared them with a conventional continuous corn system. Alternative cropping systems were chosen because of their potential to provide superior biomass yields (triticale/sorghum); some biomass yield while mitigating some negative environmental impacts (corn-soy-triticale/soy and corn-switchgrass); or some short-term biomass yield and superior long-term yield while strongly mitigating negative environmental impacts (triticale/aspen). As crop performance is strongly tied to site factors, we are evaluating these bio-mass cropping systems across a series of landscape positions.

Materials and Methods

We are achieving our goal through a long-term, randomized, replicated block experiment that tests and compares the five cropping systems across five landscape positions, implemented in 2008–09 with this initial funding from the Leopold Center for Sustainable Agriculture and Iowa State University's College of Agriculture and Life Sciences and Department of Agronomy. Startup funds have allowed us to leverage outside funding from the USDA National Institute for Food and Agriculture, U.S. Forest Service, National Science Foundation, and others, and expand beyond our initial project objectives. At present, field and lab measurements evaluate and compare 1) energy/fertilizer in-puts, 2) biomass outputs, 3) establishment, production, harvest, and transport costs, 4) water use and quality impacts, 5) above- and below-ground pools and fluxes of carbon and nitrogen, and 6) rates of greenhouse gas emissions across cropping systems and landscape positions. We are currently in the process of publishing initial project results and expect to run the experiment for 10+ years to provide enough time to rigorously establish the productivity, costs, and environmental impacts of biomass cropping systems. Long-term data are essential for determining the full impacts of our experimental systems because of seasonal variability in weather and the temporal lag in the detection of some measures of interest (e.g., carbon storage).

Results and Discussion

In the short term, we have quantified the initial agronomic, economic, and environmental impacts of establishing diverse biomass systems and compared them with a conventional corn system. Some initial research findings include:

- Baseline soil quality differs substantially across landscape positions, including levels of soil aggregation and organic matter pools, which can affect crop yield, water quality, and the potential for future soil carbon storage in the long term.

- Establishment of perennial crops including both switchgrass varieties (Cave-In-Rock and Kanlow) and the Crandon aspen clone was successful across all landscape positions.
- Continuous corn and other cropping systems containing corn experienced the highest bio-mass yield overall, but were also associated with the highest nitrate-nitrogen ($N0_3$-N) concentrations in the root zone; thus posing the largest potential threat to surface water quality.
- Triticale-sorghum was the second highest yielding cropping system, but also posed the greatest challenges in terms of timely management with seasonal weather variation and weed pressure.
- Both continuous corn and soy-triticale/soy-corn systems are profitable at biomass prices of $18/ton per acre; triticale-aspen is profitable at $36/ton per acre; and corn-switchgrass is profitable at $53/ton per acre. The triticale/aspen system is the most profitable under the high price scenario $53/ton per acre, but this price for biomass is not expected without substantial adjustments in energy markets.

In the long term, this project will improve knowledge among producers, managers, policy makers, and the public to more effectively manage agricultural lands for multiple benefits, including biomass yield, energy security, and environmental benefits important to society. The Landscape Biomass Project research and demonstration site is already being extensively used for educational purposes, including the education of students, farmers, individuals from the agribusiness and bioenergy industries, and the public on implementation, benefits, and costs of diverse, site-appropriate biomass cropping systems.

Important project accomplishments to date include:

- Establishment of a fully instrumented research and demonstration site.
- Successful collaboration among 13 departments, colleges, centers, and other units at Iowa State University and three federal research labs.
- Generation of over $3.8 million of funding—representing a 41:1 return on the initial investment from the Leopold Center—to support project development, implementation, and data collection.
- Establishment of a 10-member Farmer Advisory Board.
- Training of 29 undergraduate student research assistants, 17 graduate students, and one postdoctoral fellow.
- Over 50 presentations to diverse audiences through numerous professional meetings, classroom, and web-based outlets.
- Eight theses, dissertations, and scientific papers at various stages in the publication process.

In sum, we have largely met, and in some cases exceeded, the initial objectives in establishing the project. By attracting additional investigators and leveraging additional funds, the overall Landscape Biomass Project now represents a cutting edge, transdisciplinary, and collaborative field research and demonstration site for the continued development of sustainable biomass crops for the 21st Century.